

Appendix D
Air Emission Modeling Results

Appendix D

Radionuclide Emissions from Excavation Activities TAN TSF-06, Area B Site and TSF-26

The assumptions and calculations used to determine the air emissions of particulates and radionuclides that could result from planned remediation activities at the TAN TSF-06, Area B site and TSF-26 are presented. These calculations satisfy the requirements of 40 CFR 61.92, 61.93, and 61.94(a) NESHAPs for Emissions of Radionuclides Other than Radon from DOE Facilities and IDAPA 16.01.01.585 and .586 Toxic Substances identified as applicable requirements in the *Record of Decision for Test Area North, Operable Unit 1-10* (DOE-ID 1999).

Air emissions of particulates and radionuclides from the planned remediation activities were estimated as detailed in Attachment D1. These estimates were then used in the CAP88PC model (DOE-HQ 1997), a DOE developed and EPA approved computer code, to calculate the radionuclide dose to a receptor at the nearest site boundary and nearest community. The outputs from the CAP88PC model are included as Attachment D2.

The TAN TSF-06, Area B site to be remediated consists of a 15- x 30-m (500- x 100-ft) area of soil contaminated by windblown radioactive particles. This area includes a 500-foot section of Snake Avenue, an asphalt road. Contamination is suspected of extending beneath the roadbed. The selected remedy for this site is the excavation of contaminated to depths as indicated in Table D-1. The maximum depth of 3-m (10-ft) or the maximum depth at which contaminant concentrations are above the final remediation goals, whichever is less will be remediated. TSF-26 soils to be remediated include 137- x 53-m (450- x 175-ft) (DOE-ID 1997) to an average depth of 1.5-m (5-ft) consistent with the Group 1 remediation strategy (DOE-ID 1999).

The contaminants of concern (COC) for TSF-06, Area B and TSF-26 are Cs-137 and Co-60. The maximum activities detected for these COCs in samples taken from TSF-06, Area B were 150 and 0.185 pCi/g, respectively. For TSF-26, the maximum activities were 4,400 and 3.6 pCi/g (DOE-ID 1997). The Cs-137 activity was used to estimate emissions for both Cs-137 and its daughter Ba-137m. Other potential contaminants included trichloroethene, 1,1,1-trichloroethane, and carbon tetrachloride; however, these potential contaminants were not detected in soils from these areas. As a result, only particulate and radionuclide emissions were calculated.

The maximum volumes to be remediated are shown in Table D-1. Releases of particulates and radionuclides during excavation are projected to occur in one of two ways: (1) become airborne during heavy equipment movement across the contaminated Area, and (2) become airborne during pickup and dropping of the soil during excavation.

Particulate emission factors and rates were calculated for both release mechanisms and for several sizes of particulate material (PM₃₀, PM₁₅, PM₁₀, PM₅, and PM_{2.5}) using the assumptions detailed in Attachment D1. The equations used (EPA 1998) and results also are presented. The emission rates were then used to calculate total particulate and radionuclide emissions for the various particle sizes.

The total emissions from both release methods for particulates (in lbs) were calculated by multiplying the emission rates by the time it takes to remove all of the contaminated material. The amount of material to be moved per hour (61.92 ton/hr) was estimated by taking the amount of material transported per dump truck load (12 yd³) times 4 loads per hour times the weight of the soil per cubic yard (1.29 ton/yd³). The time to excavate the maximum volume of soil from each site was estimated by dividing the total weight of the material by the amount of material to be moved per hour.

Table D-1. Volumes to be excavated.

	Dimensions (ft)	Depth of Excavation (ft)	Volume (ft ³)	Volume (yd ³)
TSF-06, Area B				
Asphalt Road	30 X 500	0.33	4950	183.3
Shoulders-Soil	20 X 500	0.33	3300	122.2
Soil Under Road	50 X 500	9.67	241750	8954.4
Remainder of Site	50 X 500	10	250000	9260.0
TSF-06, Area B TOTAL CONTAMINATED SOIL & ASPHALT VOLUME			500,000	18,520
TSF-26				
Contaminated Soil	450 X 175	5	393,750	14,583
TSF-26 TOTAL CONTAMINATED SOIL			393,750	14,583

Table D-2. TSF-06, Area B Emission Calculations.

	PM ₃₀	PM ₁₅	PM ₁₀	PM ₅	PM _{2.5}
1. Total Volume of Contaminated Material to be removed (yd ³)	18,520	18,520	18,520	18,520	18,520
2. Weight of Contaminated Material to be removed (tons)	23,883	23,883	23,883	23,883	23,883
3. Unpaved Road Particulate Emission Rates (lbs/hr) ¹	0.46	-	0.14	-	0.02
4. Pickup and Dropping Particulate Emission Rates (lbs/hr) ¹	0.06	0.04	0.03	0.02	0.01
5. Amount of Material Moved per hour (Ton/hr)	61.92	61.92	61.92	61.92	61.92
6. Time to Remove Contaminated Material (hrs)	386	386	386	386	386
7. Road Particulate Emissions (lbs) ²	176	-	54	-	7.8
8. Pickup/Drop Particulate Emissions (lbs) ²	23	15	11	6.3	3.4
9. Cs-137 (pCi/g)	150				
10. Cs-137 (Ci/lb)	6.8E-8				
11. Ba-137m (pCi/g) ³	150				
12. Ba-137m (Ci/lb)	6.8E-8				
13. Co-60 (pCi/g)	0.185				
14. Co-60 (Ci/lb)	8.39E-11				
15. Cs-137 Release (Ci)	1.35E-05	1.02E-06	4.40E-06	4.25E-07	7.69E-07
16. Ba-137m Release (Ci)	1.35E-05	1.02E-06	4.40E-06	4.25E-07	7.69E-07
17. Co-60 Release (Ci)	1.67E-08	1.26E-09	5.43E-09	5.25E-10	9.48E-10
Releases shown are combined total release from both scenarios. The input to CAP-88 was the sum for each nuclide.					

PM_x = particulate matter, x microns or less in diameter

¹ Calculations of the Unpaved Road and Pickup/Drop Emission rates are described in Attachment D1 along with worksheet calculation summary.

² Emissions (Lines 7*8) = Emission Rates (Lines 3 & 4) X Time to Remove (Line 6). Calculation worksheet summary is included in Attachment D1

³ Ba-137m is the daughter product of Cesium-137. Approximately 85% of Cesium-137 decays to Ba-137m. In these calculations it is assumed that 100% of Cs-137 will decay to Ba-137m.

Table D-3. TSF-26 Emission Calculations.

	PM ₃₀	PM ₁₅	PM ₁₀	PM ₅	PM _{2.5}
1. Total Volume of Contaminated Material to be removed (yd ³)	14,583	14,583	14,583	14,583	14,583
2. Weight of Contaminated Material to be removed (tons)	11,288	11,288	11,288	11,288	11,288
3. Unpaved Road Particulate Emission Rates (lbs/hr) ¹	0.46	-	0.14	-	0.02
4. Pickup and Dropping Particulate Emission Rates (lbs/hr) ¹	0.06	0.04	0.03	0.02	0.01
5. Amount of Material Moved per hour (Ton/hr)	61.92	61.92	61.92	61.92	61.92
6. Time to Remove Contaminated Material (hrs)	304	304	304	304	304
7. Road Particulate Emissions (lbs) ²	138	-	42	-	6.2
8. Pickup/Drop Particulate Emissions (lbs) ²	18	12	8.6	4.9	2.7
9. Cs-137 (pCi/g)	4,400				
10. Cs-137 (Ci/lb)	2.0E-06				
11. Ba-137m (pCi/g) ³	4,400				
12. Ba-137m (Ci/lb)	2.0E-8				
13. Co-60 (pCi/g)	3.6				
14. Co-60 (Ci/lb)	1.6E-09				
15. Cs-137 Release (Ci)	3.8E-04	2.4E-05	1.0E-05	9.8E-06	1.8E-05
16. Ba-137m Release (Ci)	3.8E-04	2.4E-05	1.0E-05	9.8E-06	1.8E-05
17. Co-60 Release (Ci)	2.6E-07	1.9E-08	8.3E-08	8.0E-09	1.4E-08
Releases shown are combined total release from both scenarios. The input to CAP-88 was the sum for each nuclide.					

PM_x = particulate matter, x microns or less in diameter

¹ Calculations of the Unpaved Road and Pickup/Drop Emission rates are described in Attachment D1 along with worksheet calculation summary.

² Emissions (Lines 7*8) = Emission Rates (Lines 3 & 4) X Time to Remove (Line 6). Calculation worksheet summary is included in Attachment D1

³ Ba-137m is the daughter product of Cesium-137. Approximately 85% of Cesium-137 decays to Ba-137m. In these calculations it is assumed that 100% of Cs-137 will decay to Ba-137m.

Assuming that the radionuclide contamination is homogeneously distributed throughout the soil and will be released with particulates, radionuclide activity released (in Ci) was then calculated by multiplying the total particulate emissions by the nuclide-specific soil concentrations (in Ci/lb). The activities were then summed, on a nuclide-specific basis for input to the CAP-88 model.

Exposures were modeled at two distances: 150 m and 16,000 m. These distances were selected to correspond with the nearest public access location approximately 150 m to the east where County Road #133 intersects with Lincoln Blvd, the road from TAN to CFA to the south, and the nearest community (Mud Lake, Idaho approximately 16,100 m to the east).

Results for TSF-06, Area B indicate that the total effective dose equivalent rates generated by the model were a maximum rate of $3.4\text{E-}04$ mrem/year to an individual at the site boundary (150-m to the east) and $1.10\text{E-}04$ mrem/year for all quadrants located 16,100-m from the source (including Mud Lake, Idaho). These doses are those estimated by the CAP-88PC model to be received by an individual over an entire year at the emission rate calculated. However, emissions of dust and radionuclides from the remedial activity planned would be for a much shorter period of time (approximately 12 weeks). Estimated doses for both locations are well below the NESHAPS limit of 10 mrem/yr.

Results for TSF-26, indicate that the total effective dose equivalent rates generated by the model were a maximum rate of $5.3\text{E-}03$ mrem/year to an individual at the site boundary (150-m to the east) and $1.7\text{E-}03$ mrem/year for all quadrants located 16,100-m from the source (including Mud Lake, Idaho). These doses are those estimated by the CAP-88PC model to be received by an individual over an entire year at the emission rate calculated. Estimated doses for both locations are well below the NESHAPS limit of 10 mrem/yr.

The CAP88PC output including the synopsis, general data, weather data, and dose and risk equivalent summaries Attachment D2 to this appendix.

References

EPA 1998, *Compilation of Air Pollutant Emission Factors, AP-42, Fifth Edition, Volume I: Stationary Point and Area Sources*, January 1995 (Section 13.2.4) and September 1998 (Section 13.2.2).

DOE-HQ 1997, *CAP88-PC Version 2.0 User's Guide*. US Department of Energy, ER-8/TN, June 1997.

DOE-ID 1997, *Comprehensive Remedial Investigation Feasibility Study (RI/FS) for Test Area North OU 1-10 at INEEL*. U.S. Department of Energy Idaho Operations Office, DOE/ID-10557, November 1997.

DOE-ID 1999, *Final Record of Decision for Test Area North, Operable Unit 1-10*. Idaho National Engineering and Environmental Laboratory, Idaho Falls, Idaho. DOE/ID-10682, October 1999.

Attachment D1
Emission Calculations

Attachment D1

Emission Calculations

Problem Statement:

Estimate the fugitive dust particle distribution associated with remediation activities of the TAN site TSF-06, Area B and TSF-26.

Approach:

Methods to estimate fugitive particulate matter (PM) generated from unpaved roads and aggregate handling and storage piles from the most recent revisions (by section) of AP- 42, Chapter 13 (EPA 1998), were used to estimate dust emissions from remedial activities at the TAN TSF-06, Area B site. The PM₃₀, PM₁₅, PM₁₀, PM₅, and PM_{2.5} distributions were calculated and used in the CAP88PC model (DOE-HQ 1997) to estimate radionuclide/dust emissions and dose to receptors at the nearest site boundary and nearest community.

Assumptions used in the calculations:

The remedial action will occur between March and October in the year 2000 (245 days).

The average silt loading or percent of silt in the soils to be remediated is characteristic of soils at TAN (8.07%) (an average of silt content sample results for TAN soils as presented in INEL [1995])

Averages used for the number of wheels per vehicle for those to be driven on the contaminated area (excludes dump trucks), and weights of excavation equipment are listed in Table D1-1.

Wind erosion is minimal and is not included.

The total vehicle miles traveled on the contaminated surface (VMT) are 0.1 mile/hr.

Each dump truck transports 12 cubic yards (yd³) of material.

Average soil moisture content was assumed to be 6.0% (assumed appropriate for INEEL soils in previous estimates)

Monthly average wind speed and direction (quadrant) for the CFA at the 20-foot and 250-foot levels were taken from Clawson (1989). The average wind speeds were determined by using the weighted-average of the months of March through October. The average wind speed for the 20-foot level, WSW quadrant (8.2 mph) was used in the calculation of particulate emissions generated from pickup and dropping during excavation.

Table D1-1. Estimated equipment to be used.

Equipment	Number of Wheels	Weight (lbs)	Number
416B Backhoe Loader	4	13,700	1
950 Front End Loader	4	36,500	1
D6 Dozer	4	40,000	1
140H Grader	6	30,000	1
838 Soil Compactor	4	44,000	1
Dump Truck	10	50,000	14
Water Truck	10	50,000	1
Average without Dump Trucks	5.3	35,700 (17.85 Ton)	

Calculations of Particulate Emissions from Unpaved Roads:

To estimate the quantity of size specific particulate emissions from an unpaved road, per vehicle mile traveled, first an emission factor for each size of particulate matter was calculated using an equation taken from AP-42, Section 13.2.2, Unpaved Roads, 9/98 revision (EPA 1998). The equation and definition of terms are as follows:

$$E_f = k[(s/12)^a(W/3)^b]/(M/0.2)^c$$

Where:

E_f = size-specific emission factor (lb/VMT)

s = surface material silt content (%)

W = mean vehicle weight (tons)

M = surface material moisture content (%)

Where k , a , b , and c are empirical constants provided in Section 13.2.4 (9/98 revision) of AP-42:

Constant	PM-2.5	PM-10	PM-30
k (lb/VMT)	0.38	2.6	10
A	0.8	0.8	0.8
B	0.4	0.4	0.5
C	0.3	0.3	0.4

Using the calculated E_f (lbs/VMT), an assumed VMT of 0.1 mph on the contaminated surface, and the site-specific tonnage estimates for the remediation, the emission rates in total lbs and lbs/hr was calculated. The outputs of the calculations are summarized, by site, in Tables D.2 and D.3. Worksheet summaries are also included in this attachment.

Calculations of Particulate Emissions from Pickup and Dropping of Soil during Excavation/Loading:

To estimate the quantity of size specific particulate emissions generated from pickup and dropping during excavation, an emission factor for each size of particulate matter was calculated using an equation from taken from EPA (1998), Section 13.2.4, Aggregate Handling and Storage Piles. The equation and definition of terms are as follows:

$$E_f = k (0.0032) [U/5]^{1.3} / (M/2)^{1.4}$$

Where:

E_f = emission factor (pounds/Ton)

k = particle size multiplier (dimensionless)

U = mean wind speed, (8.2 mph)

M = soil moisture content (6%)

Where k is a dimensionless constant from EPA (1998) Section 13.2.2 (1/95) revision of AP-42:

PM-2.5	PM-5	PM-10	PM-15	PM-30
0.11	0.2	0.35	0.48	0.74

Using the E_f the emission rates in lbs/ton and lbs/hr was calculated. The outputs of the calculations are summarized, by site, in Tables D.2 and D.3. Worksheet summaries are also included in this attachment.

The emission rates for both excavation activities were then used to estimate total particulate emissions to be then used in the CAP88PC model. Emission factors and emission rates for both activities are presented in Tables D-2 and D-3 of the appendix text.

References:

Clawson 1989, *Climatology of the Idaho National Engineering Laboratory*, Second Edition, U.S. Department of Commerce, National Oceanic and Atmosphere Administration, Environmental Research Laboratories, Air Resources Laboratory, Field Research Division, December 1989.

DOE-HQ 1997, *CAP88-PC Version 2.0 User's Guide*. US Department of Energy, ER-8/TN, June 1997.

EPA 1998, *Compilation of Air Pollutant Emission Factors, AP-42*, Fifth Edition, Volume I: *Stationary Point and Area Sources*, January 1995 (Section 13.2.4) and September 1998 (Section 13.2.2).

INEL 1995, *Draft Final Report of the WAG 3 and WAG 10 Radionuclide-Contaminated Soils Treatability Study*, Appendix A, INEL-94/0171, October 1995.

TSF-06, Area B

Site Dimensions:	feet	30	500	0.33	Asphalt Road
	meters	9.15	152.5	0.10065	
	feet	20	500	0.33	Shoulders-Soil
	meters	6.1	152.5	0.10065	
	feet	50	500	9.67	Soil Under Road
	meters	15.25	152.5	2.94935	
	feet	50	500	10	Remainder of Site
	meters	15.25	152.5	3.05	
	Volume (ft3)	500000			
	Volume (m3)	14186.3125			
	Volume (yd3)	18518.5185			
	Weight Tons	23888.8889			
	Weight Lbs	4777777.8			short ton conversion

COC	Maximum pCi/g	pCi/lb	Ci/lb	lbs waste	Ci total	tons waste
Cs-137	150	68040	6.804E-08	47777778	3.25080002	23889
Co-60	0.185	83.916	8.3916E-11	47777778	0.00400932	23889
Ba-137m	150	68040	6.804E-08	47777778	3.25080002	23889

Pickup & Dropping

k, particle size multiplier:

PM30	PM15	PM10	PM5	PM2.5
0.74	0.48	0.35	0.2	0.11

Aerodynamic particle size multiplier (k) from Section 13.2.4

Emission factor - Ef (lbs/ton) =		Ef	=	k*
0.0009694	0.0006288	0.0004585	0.000262	0.0001441

0.00130761 Using equation for aggregate handling & storage piles - Section 13.2.4
Wind speed = 8.2 mph; Moisture = 6 %

Emission total - Et (lbs) - total pounds released based on total tons of waste		=	Et*tons	
23.1579966	15.0214032	10.9531065	6.258918	3.4424049

Emission rate - Er (lbs/hr) - pounds releases bases on time estimated to remove total tons	=	Et/386 hr
0.060025527 0.03893548 0.02839045 0.016223115 0.00892271		385.8024691

Based on an estimate of moving 61.92 ton/hr which was estimated by taking the material transported per dump truck load (12 yd3) times 4 loads per hour times the weight of soil per yd3 (1.29 ton/yd3)

	PM30	PM15	PM10	PM5	PM2.5
	Ci released	Ci released	Ci released	Ci released	Ci released
Cs-137	1.5757E-06	1.0221E-06	7.45249E-07	4.2586E-07	2.3422E-07
Co-60	1.9433E-09	1.2605E-09	9.19141E-10	5.2522E-10	2.8887E-10
Ba-137m	1.5757E-06	1.0221E-06	7.45249E-07	4.2586E-07	2.3422E-07

Unpaved Road - a.k.a excavation of the source

k, particulate size constants (multipliers)

PM30	PM10	PM2.5
10	2.6	0.38
exponential - a		
0.8	0.8	0.8
exponential - b		
0.5	0.4	0.4
exponential - c		
0.4	0.3	0.3

Emission Factor (E) - size-specific Ef in lb/VMT

4.555791206	1.39250765	0.20352035
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VMT is Vehicle Mile Travelled per hr - 0.1.

Emission total (lbs) - total lbs released based on total VMT of 0.1 mile traveled per hr on the contaminated surface * 386 hr total to remove = 38.6

175.8535405	53.7507952	7.85588545
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Emission rate (lbs/hr)

0.455812377	0.13932206	0.02036246
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	PM30 Ci released	PM15 Ci released	PM10 Ci released	PM5 Ci released	PM2.5 Ci released
Cs-137	1.1965E-05	0	3.6572E-06	0	5.3451E-07
Co-60	1.4757E-08	0	4.51055E-09	0	6.5923E-10
Ba-137m	1.1965E-05	0	3.6572E-06	0	5.3451E-07

Subtotal:

	PM30	PM15	PM10	PM5	PM2.5	Total
Cs-137	1.3541E-05	1.0221E-06	4.40245E-06	4.2586E-07	7.6874E-07	2.01598E-05
Co-60	1.67E-08	1.2605E-09	5.42969E-09	5.2522E-10	9.4811E-10	2.48638E-08
Ba-137m	1.3541E-05	1.0221E-06	4.40245E-06	4.2586E-07	7.6874E-07	2.01598E-05

TSF-26 (I.e., PM2A Tank Soils)

Site Dimensions:	feet	450	175	5
	meters	137.25	53.375	1.525
	Volume (ft3)	383750		
	Volume (m3)	11171.7211		
	Volume (yd3)	14583.3333		
	Weight Tons	18812.5		
	Weight Lbs	37825000		

450x175' from RI/FS Figure 4-31, page 4-101; 3' from Group 1 Remediation strategy

short ton conversion

COC

	pCi/g	pCi/lb	Ci/lb	lbs waste	Ci total	tons waste
Cs-137	4400	1995840	1.99584E-06	37825000	75.08348	18812.5
Co-60	3.6	1632.96	1.63296E-09	37825000	0.06144012	18812.5
Ba-137m	4400	1995840	1.99584E-06	37825000	75.08348	18812.5

Pickup & Dropping

k, particle size multiplier:

PM30	PM15	PM10	PM5	PM2.5
0.74	0.48	0.35	0.2	0.11

Aerodynamic particle size multiplier (k) from Section 13.2.4

Emission factor - Ef (lbs/ton) =					Ef	=	k*	0.00130761
0.0009694	0.0006288	0.0004585	0.000262	0.0001441				

Using equation for aggregate handling & storage piles - Section 13.2.4
Wind speed = 8.2 mph; Moisture = 6 %

Emission total - Et (lbs) - total pounds released based on total tons of waste						=	Et*tons	
18.2368375	11.8293	8.6253125	4.928875	2.71088125				

Emission rate - Er (lbs/hr) - pounds releases bases on time estimated to remove total tons						=	Er/304 hr	
0.060025248	0.0389353	0.02839032	0.01622304	0.00892267			303.819444 hrs	

Based on an estimate of moving 61.92 ton/hr which was estimated by taking the material transported per dump truck load (12 yd3) time 4 loads per hour times the weight of soil per yd3 (1.29 ton/yd3)

	PM30	PM15	PM10	PM5	PM2.5
	Ci released	Ci released	Ci released	Ci released	Ci released
Cs-137	3.6398E-05	2.3609E-05	1.72152E-05	9.8372E-06	5.4105E-06
Co-60	2.978E-08	1.9317E-08	1.40851E-08	8.0487E-09	4.4268E-09
Ba-137m	3.6398E-05	2.3609E-05	1.72152E-05	9.8372E-06	5.4105E-06

Unpaved Road - a.k.a excavation of the source

k, particulate size constants (multipliers)

PM30	PM10	PM2.5
10	2.6	0.38
exponential - a		
0.8	0.8	0.8
exponential - b		
0.5	0.4	0.4
exponential - c		
0.4	0.3	0.3

Emission Factor (E) - size-specific Ef in lb/VMT

VMT is Vehicle Mile Travelled per hr = 0.1.

4.555791206 1.39250765 0.20352035

Emission total (lbs) - total lbs released based on total VMT of 0.1 mile traveled per hr on the contaminated surface * 304 hr total to remove = 30.4

30.4

138.4960527 42.3322325 6.18701859

Emission rate (lbs/hr)

0.455849865 0.13933352 0.02036413

	PM30	PM15	PM10	PM5	PM2.5
	Cl released	Cl released	Cl released	Cl released	Cl released
Cs-137	0.00027642	0	8.44884E-05	0	1.2348E-05
Co-60	2.2616E-07	0	6.91268E-08	0	1.0103E-08
Ba-137m	0.00027642	0	8.44884E-05	0	1.2348E-05
Subtotal:					
Cs-137	0.00031281	2.3609E-05	0.000101704	9.8372E-06	1.7759E-05
Co-60	2.5594E-07	1.9317E-08	8.3212E-08	8.0487E-09	1.453E-08
Ba-137m	0.00031281	2.3609E-05	0.000101704	9.8372E-06	1.7759E-05

Total

0.00048572

3.8105E-07

0.00048572